PHENIX YAG LASER OPERATING PROCEDURE IN BUILDING 1008A

procedure name

PHENIX Procedure No. PP-2.5.2.9-04

Revision: C **Date: 11/17/2009**

Hand Processed Changes

HPC No.	Date	Page Nos.	Initials

Approvals

11/19/09
PHENIX S E & I Date

11/19/09
Cognizant Scientist/Engineer /Date
/Activity Manager

11-19-09
PHENIX Safety Date

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_____ _____

PHENIX S E & I Date Cognizant Scientist/Engineer Date /Activity Manager

_____ _____

PHENIX Safety Date

_____ _____

REVISION CONTROL SHEET

LETTER	DESCRIPTION	DATE	AUTHOR	APPROVED BY	CURRENT OVERSIGHT
A	First Issue	n/a	n/a	n/a	n/a
B	No record of changes from rev. A (Note: reviewed by S. Stoll 6/4/2007 and found to be up to date without further revision)	10/10/2003	n/a	E. O'Brien, C. Woody, W. Lenz, A. Etkin	D. Lynch
C	Reviewed and found to be up-to-date. Added attachments to the master pdf's.	11/18/2009	D. Lynch	P. Giannotti, D. Lynch, R. Pisani	D. Lynch

Procedure for Operating YAG Laser in Building 1008A

1.0 Purpose and Scope

The purpose of this document is to describe the safety issues pertaining to operating a Continuum Surelite II-10 Nd:YAG laser in building 1008A (also known as the PHENIX Counting House). This procedure applies in accordance with the **BNL Laser Controlled Area Standard Operating Procedure** which accompanies this document. The laser and its safety enclosures are also described in the accompanying memos and references.

2.0 Responsibilities

All personnel operating the laser are required to be properly trained as specified in this procedure. In addition, they are responsible to ensure that no unauthorized personnel are inside the room housing the laser (henceforth referred to as the "laser hut") while the laser is in an open operating mode (see below), and to insure that the laser is left in a closed and interlocked mode for normal operations.

3.0 Precautions

The laser is potentially capable of delivering Class IV laser light, and as such, it has been installed inside a multiply interlocked enclosure to allow operation in certain work areas as a Class I device. The laser shall only be operated in the designated laser hut in building 1008A. Operations in other locations will require the approval of the RHIC ES&H Coordinator and the Laser Safety Officer. The laser hut will be posted indicating the type, class and power of the laser inside, and that entry is permitted only by authorized personnel while the laser is operated with the box open. These signs shall be approved by the BNL Laser Safety Officer.

4.0 Prerequisites

The laser shall only be operated by authorized personnel. To be authorized, you must pass the BNL Laser Safety Training Course (IND011), take the required eye exam, and receive instructions on the safety systems and use of this particular laser. A list of authorized operators will be posted outside the laser hut.

5.0 Required equipment

Laser safety goggles which are approved for use with Nd:YAG lasers operating at the primary, secondary and third harmonic wavelengths (optical density greater than 7 at 1064 nm, 532 nm and 355 nm) must be worn inside the laser hut at all times whenever the box is open and the laser is capable of emission. Specifications for these goggles are given in the Standard Operating Procedure.

6.0 Procedure

The startup and operating procedure for the laser is described in the Surelite II-10 operating manual supplied by the manufacturer (see Ref.1) and the laser shall be operated in accordance with this procedure at all times.

Normal operation of the laser for the purpose of calibrating the PHENIX electromagnetic calorimeter, beam-beam, and time-of-flight detectors does not require opening the interlocked box, which serves as a safety enclosure for both the laser and the internal beam splitter optics, and is considered a Class I mode of operation (all beams fully enclosed). In normal Class I operation, authorized users, such as the PHENIX Shift Crew, may perform simple operations using the laser. These operations are limited to those listed in the Standard Operating Procedure. For this type of operation, only passive entry into the laser hut is required to access the controls on the laser power supply and control module.

In order to make adjustments to the optics *inside* the laser box while the laser is running, the laser hut must be cleared of all unauthorized personnel. The operator must notify any personnel working in the area that the laser is being operated in an open mode inside the room. A watch person must be stationed outside the hut to prevent any unauthorized personnel from entering the hut when the box is open. The watch person must also insure that no one is working overhead who could inadvertently be exposed to any laser emission.

In order to make adjustments to the laser or optics inside the laser box when the laser is running, part of the normal safety interlock system must be bypassed. All such bypasses shall be removed and the laser returned to its normal interlocked state before the laser is operated in its normal operating mode. All active fiber outputs from the box shall be connected or capped.

7.0 Safety and interlock system

The safety and interlock system for the laser box is integrated into the safety and interlock system of the laser itself supplied by the manufacturer. The system is designed such that the internal shutter inside the laser cavity drops into place whenever the box is opened and prevents the laser from firing.

Verification that the internal shutter drops into place when the lid is opened and no light is emanating from the laser shall be done using a light sensitive photodiode inside the laser box according to the procedure described in the Standard Operating Procedure. The system shall be tested every six months to insure that it is functioning correctly, and the results of the tests will be recorded in a logbook located in close proximity to the laser.

8.0 References

8.1 Continuum Surelite II-10 Operators Manual

9.0 Attachments

9.1 BNL Laser Controlled Area Standard Operating Procedure (ESH-0002)

9.2 Memo dated August 10, 1998

9.3 Memo dated August 6, 1998

9.4 Memo dated September 12, 1996

9.4 Drawing of laser box dated August 19, 1996

BROOKHAVEN NATIONAL LABORATORY
LASER CONTROLLED AREA
STANDARD OPERATING PROCEDURE (SOP)

This document defines the safety management program for the laser system listed below. All American National Standard Institute (ANSI) Hazard Class 3b and 4 laser systems must be documented, reviewed, and approved through use of this form. Each system must be reviewed annually.

System description: Continuum Surelite II-10
Location: 1008-A

LINE MANAGEMENT RESPONSIBILITIES

The Owner/Operator for this laser is listed below. The Owner/Operator is the Line Manager of the system and must ensure that work with this laser conforms to the guidance outlined in this form.

Owner/Operator:

Name: Craig Woody *Signature:* *Date:* 10/10/03

AUTHORIZATION

Work with all ANSI Class 3b and 4 laser systems must be planned and documented with this form. Laser system operators must understand and conform to the guidelines contained in this document. This form must be completed, reviewed, and approved before laser operations begin. The following signatures are required.

C. Weilandics

BNL LSO printed name *Signature* *Date*

A.Etkin

ES&H Coordinator printed name *Signature* *Date*

APPLICABLE LASER OPERATIONS
x General Operation x Alignment x Service/Repair □ Specific Operation x Fiber Optics

ANALYZE THE LASER SYSTEM HAZARDS

Hazard analysis requires information about the laser system characteristics and the configuration of the beam distribution system.

LASER SYSTEM CHARACTERISTICS					
Laser Type *(Argon, CO2, etc)*	Wavelengths	ANSI Class	Maximum Power of Energy/Pulse	Pulse Length	Repetition Rate
YAG:Nd	1064 nm 532 nm 355 nm	4 4 4	600 mJ 260 mJ 215 mJ	7 ns	10 Hz

☐ **Cryogen Use**

Describe type, quantity, and use.

_____

☐ **Chemicals & Compressed Gasses**

Describe type, quantity, and use.

_____

☒ **Electrical Hazards**

Description *(Describe the power supply to the system).*

The factory supplied power supply operates from 220V power. No hazardous voltages are exposed during normal use. Servicing the power supply or operating the laser head with the interlocks defeated may only be carried out by qualified and authorized personnel with proper electrical safety training. Working hot rules apply whenever hazardous voltages are exposed during service operations.

☒ **Other Special Equipment**

Description *(Equipment used with the laser(s)).*

Beam splitter optics – 6 mirrors with lenses and fiber optics, 2 mirrors without lenses with fiber optics

Laser System Configuration: Describe the system controls *(keys, switch panels, computer controls),* beam path and optics *(provide a functional/block diagram for complicated beam paths)*.

This laser is used to deliver light pulses to three of the PHENIX subsystem detectors (EMCAL, Beam-Beam and Time-of-Flight) for energy and time calibration. Light from the laser is split by a series of beam splitter optics and delivered to the three subsystems over a set of long optical fibers. The laser and its beam splitter optics are enclosed in a multiply interlocked box which serves as a controlled area. Therefore, when the interlock box is closed and operational, the laser can be operated in a Class I (fully enclosed) mode. However, the possibility for exposure to dangerous beams of both visible and invisible light exist inside the box, and only trained and authorized personnel may operate the laser with the box open and the interlocks defeated.

The laser and its beam splitter optics are shown in the diagram attached to this procedure. The laser incorporates a second and third harmonic generator to produce beams of 532 nm and 355 nm light in addition to the primary beam at 1064 nm. The beam at 532 is in the visible (green), while the 355 nm beam is in the UV and the 1064 nm beam is in the infrared and are not visible. A factory supplied beam separator package (SSP) splits the beam into these three wavelengths.

The EMCAL uses light from the third harmonic at 355 nm for energy and time calibration. The light is first reduced by a factor of 10 by a fixed mirror before reaching a second variable attenuator. This attenuator is computer controlled from outside the box and does not require access to the laser or the beam splitter optics to control the beam intensity to the detector. After the variable attenuator, the beam is split into six equal intensity secondary beams by a set of partially reflecting mirrors. Each of the secondary beams is focused with a lens onto the end of a fiber which carries the light to a series of optical connectors on the side of the laser box. The amount of energy injected into each fiber and that appears at the output connectors is < 5mJ/pulse. These connectors are used to couple to another set of long optical fibers which transport the light over a distance of approximately 50m to each of the six EMCAL sectors The light from each of these fibers is further split into multiple fibers on the detector, such that the light actually reaching each individual detector element is very low (< 0.1 microjoule/pulse).

The Beam-Beam counters use the second harmonic at 532 nm, and the Time-of-Flight system uses the third harmonic at 355 nm. For both of these systems, a low power reflection from a clear window in the beam path is used to inject a small amount of light into a fiber which again carries the light to a set of connectors on the side of the laser box. Additional neutral density filters are used to further reduce the light intensity to < 1 microjoule/pulse at the connectors. As in the case of the EMCAL, another set of long optical fibers are used to transport the light over a distance of ~ 50 m to the detector where the light is further split into multiple fibers which go to each individual detector element. In this case, the energy of the light reaching each detector element is extremely low (< 1 picojoule/pulse).

The laser box itself sits inside a separate room in the PHENIX Counting House (1008-A) which can serve as an additional controlled area when the laser is being aligned or serviced. The power supply is key locked and only operated by authorized personnel. **Only operators authorized by this procedure are allowed to operate the laser with the interlock box open for alignment or service**. However, authorized users, such as PHENIX personnel on shift, may use the laser for calibration purposes and perform simple operations using the laser as listed below.

DEVELOP CONTROLS
IDENTIFY ES&H STANDARDS

Recognition, evaluation, and control of laser hazards are governed by the following documents.

American National Standards Institute (ANSI) Standard for Safe Use of Lasers;

(ANSI Z136.1-2000)

Laser Safety Subject Area

Brookhaven National Laboratory Environment Safety and Health Standard: 1.5.3 INTERLOCK SAFETY FOR PROTECTION OF PERSONNEL

ENGINEERING CONTROLS

☒ Beam Enclosures	☒ Protective Housing Interlocks	☐ Other
☒ Beam Stop or Attenuator	☒ Key Controls	
☒ Activation Warning System	☒ Other Interlocks	
☒ Ventilation	☐ Emission Delay	

Describe each of the controls in the space provided below this text. Interlocks and alarm systems must have a design review and must be operationally tested every six months. Controls incorporated by the laser manufacturer may be referenced in the manuals for these devices. **Attach a copy of the design review documentation and a written testing protocol. Attach or keep elsewhere any completed interlock testing checklists to document the testing history.**

Laser was approved for operation in Building 1008 as part of the PHENIX Operational Readiness Review (ORR) on December 12, 1997. Laser operation is covered under PHENIX Operating Procedure PP-2.5.2.9-04.

Engineering Controls Description:

Beam Enclosures: Primary beam enclosures are supplied by the manufacturer for the laser and beam separator. The laser is housed inside an interlocked light tight box.

Beam Stop or Attenuator: Diffusing beam stops are installed at the end of each optical beam path. An attenuator mirror limits the intensity in 6-fold beam splitter to 10% of the total beam intensity Attenuator mirrors and filters are used to limit the intensity of the 2-fold beam splitter to <4% of the total beam intensity

Activation Warning System: A factory supplied indicator light on the control unit shows when the laser is activated. The room where laser is located has an external lighted warning sign which is lit when the laser is operated with the box open for alignment or service.

Ventilation: The room where laser is located is adequately ventilated.

Protective Housing Interlocks: Laser housing is equipped with factory supplied interlocks.

Key Controls: Laser is equipped with factory supplied key lock for operation.

Other interlocks: The laser box is equipped with four interlocks to close the main shutter when the box is opened. There is also an interlock override switch inside the box which activates the external warning light on the room when the laser is operated with the box open for alignment or service.

ADMINISTRATIVE CONTROLS

☒ Laser Controlled Area ☒ Signs ☒ Labels ☒ Operating Limits

The format and wording of laser signs and labels are mandated by BNL and ANSI standards. Only the standard signs are acceptable. Standard signs are available from the BNL Laser Safety Officer.

All lasers must have a standard label indicating the system's wavelength, power, and ANSI hazard class. Required labels must remain legible and attached. The manufacturer should label commercial systems.

Standard Operating Procedures (SOP) are required for laser system operation, alignment, and maintenance. The SOPs need only contain the steps necessary to perform these tasks and identify when and where posting and personal protective equipment is required. SOPs must be approved by the BNL Laser Safety Officer and should be kept with this program documentation.

Administrative Controls Description:

Laser Controlled Area: The laser is normally operated fully enclosed (Class 1). If it becomes necessary to perform maintenance or service on the laser and associated optics, a temporary laser controlled area will be established within the room where the laser is situated.
Signs: Appropriate laser signs are posted at the entrance to the room where the laser is situated.
Labels: Appropriate warning labels are posted on the cover of the laser

CONFIGURATION CONTROL

Prepare and attach a checklist to be used for configuration control of any protective housings, beam stops, beam enclosures, and any critical optics *(mirrors or lenses that could misdirect the beam and result in personnel hazard)*. Include entries to ensure placement of required signs and labels and status of interlock verification. Completed checklists must be posted at the laser location. The checklist does not have to be redone unless there has been a system modification, extended shutdown, or change of operations.

Prior to operation after a sustained shutdown the laser area is to be inspected to insure it conforms to this SOP and the following check list completed:
1 All sign and labels intact and in place.
2 All Fiber Optic outputs terminated.
3 Interlock certification current as per test procedure.

PERSONAL PROTECTIVE EQUIPMENT

☒ Eye Wear ☐ Skin Protection

Eye Wear: All laser protective eyewear must be clearly labeled with the optical density and wavelength for which protection is afforded. Eyewear should be stored in a designated sanitary location. Color - coding or other distinctive identification of laser protective eyewear is recommended in multi laser environments. Eyewear must be routinely checked for cleanliness and lens surface damage.

Skin Protection: For UV lasers or lasers that may generate incidental UV in excess of maximum permissible exposure (MPE), describe the nature of the hazard and the steps that will be taken to protect against the hazard.

EYE WEAR SPECIFICATIONS			
Laser System Eyewear Identification	Wavelengths	Intra-beam Optical Density	Diffuse Optical Density
YAG laser goggles (Glendale LSR-Gard B Series LGS LQO29)	1064 nm 532 nm 355 nm	>7 >7 >9	

EYE WEAR REQUIREMENTS				
Laser Type *(Argon, CO2, etc)*	Wavelengths	Intra-beam Optical Density	Diffuse Optical Density	NHZ
Nd:YAG	1064 nm 532 nm 355 nm	7(10 sec.) 6.2(0.25 sec.) 4(10 sec.)	4(600 sec) 3.6(600 sec.) 2.3(600 sec.)	18.3 m 10.8 m 2.8 m

Define eyewear optical density requirements by calculation or manufacturer reference and list other factors considered for eyewear selection. The BNL Laser Safety Officer will assist with any required calculations.

1. For invisible beams, eye protection against the full beam must be worn at all times unless the beam is fully enclosed.
2. For visible beams, eye protection against the full beam must be worn at all times during gross beam alignment.
3. Where hazardous diffuse reflections are possible, eye protection with an adequate Optical Density for diffuse reflections must be worn within the nominal hazard zone at all times.
4. If you need to operate the laser without wearing eye protection against all wavelengths present, explain the precautions that will be taken to prevent eye injury.

No protective eyeware is required when using the laser in its normal operating mode (Class 1) inside its enclosed box. **Protective eyeware is required when operating or adjusting the laser when the box is open.**

TRAINING

LASER SAFETY TRAINING

Laser Operators must complete sufficient training to assure that they can identify and control the risks presented by the laser systems they use. Owners/Operators and Qualified Laser Operators must complete the BNL World Wide Web based training course (BNL course #HP-IND-011).

Qualified Laser Operators must also complete system-specific orientation with the system owner/operator. **System-specific training must be documented with a checklist that includes**

- Trainee name and signature
- Owner/Operator signature
- Date
- Brief list of topics covered
  - Review of this program documentation
  - Review of SOPs

All laser safety training must be repeated every two years.

MEDICAL SURVEILLANCE

Operators of ANSI Class 3b and 4 laser systems must complete a baseline medical eye examination prior to laser system operation. Any qualified ophthalmologist may complete this exam. BNL has arranged for this service from the following local physicians:

Dr. Charles Rothberg 331 East Main St. Patchogue, NY 11772	The Ophthalmic Center Dr. Basilice 3400 Nesconset Highway East Setauket, NY 11733	East End Eye Associates Dr. Sherin 669 Whiskey Road Ridge, NY 11961
631 758-5300 $65 per exam	631 751-2020 $60 per exam	631 369-0777 $125 per exam

Personnel using physicians other than those listed must have their examination records forwarded to the BNL Occupational Medicine Clinic.

FEEDBACK AND IMPROVEMENT

Comments and suggestions for improvement should be directed to BNL-Laser Safety Officer, Chris Weilandics (X2593; weil@bnl.gov).

LASER USER QUALIFICATION

Personnel qualified to work with this laser system are listed below. These Qualified Laser Operators must understand the information and conform to the requirements contained in this document. For training and medical surveillance, enter the date of completion.

Qualified Laser Operators:

Basic Laser Training	Job-Specific Training	Medical Surveillance	Printed Name	Signature	Owner/Oper. Initial/date
6/27/03	yes	2/11/92	Craig Woody		
6/17/03	yes	4/22/92	Sean Stoll		

Signature above indicates that the qualified laser operator has read and understood this procedure and has been trained in the system specific operation of this laser.

TRAINING CHECKLIST

All qualified laser operators must read and understand the following system specific checklist.

- For normal Class I mode of operation, both lids of the interlocked box must be closed and all fiber optics outputs must be terminated.
- Check that interlock certification is current as per interlock test procedure.
- To operate the laser with the interlocked box open, a temporary controlled area must be established in the room where the laser located as specified by this procedure.
- Protective eyeware must be worn at all times when the laser is operated with the box open and the interlocks defeated.
- All qualified laser operators must read and understand the procedure listed below.

PROCEDURE

The following list identifies the hazards specifically associated with the laser described in this procedure.

Operation:

- All beams from the laser are normally totally contained during normal routine Class I operation and no specific eye protection is required. Light from the output fibers to the EMCAL, Beam-Beam and Time-of-Flight detectors are low power, **but one should never look directly into the fibers or into the exit ports.** The light delivered to the EMCAL and TOF fibers is at 355 nm, which is in the UV and not visible. The light delivered to the Beam-Beam counters is at 532 nm and in the visible green part of the spectrum. However, the Surelite laser is also capable of producing light at 1064 nm, which is in the infrared and is not visible. All beams are dangerous and require eye protection when the laser is operated without total beam containment.

- In normal Class I operation, authorized users, such as the PHENIX Shift Crew, may perform simple operations using the laser. These operations are limited to the following:

    - Turning the laser on and off with the key switch
    - Pushing the shutter open and close button on the front panel of the power supply
    - Resetting an error condition as indicated on the front panel by cycling the power on and off (and noting the error code in the Error log sheet)
    - Adjusting the light intensity to the EMCAL sectors by controlling the variable attenuator with the computer

    All PHENIX personnel are required to take PHENIX Awareness Training which indicates the hazards of the laser in the PHENIX Counting House, and the shift crew is required to take PHENIX shift training which specifies what they are allowed to do with the laser while on shift. All other personnel authorized to perform the above Class I operations shall have task specific training and be listed outside the laser room.

    In addition to these routine operations, authorized members of the Beam-Beam and Time-of-Flight subsystems may change the fixed neutral density filters in the Beam-Beam or Time-of-Flight fiber outputs inside the laser box. To do so, the box must be in its normal interlocked mode, and the user must push the shutter close button and check that the indicator light shows that the internal shutter has been closed before opening the box. Members of the Beam-Beam and Time-of-Flight subsystems must read and acknowledge that they have understood this procedure to become authorized to perform this operation, and a list of these authorized users will be posted outside the laser room.

    Any other operations or adjustments inside the box can only be performed by the authorized operators listed in this procedure.

Alignment:

- Alignment of the laser beam or any of the internal beam optics must be done with the interlocked box open. This requires establishing a temporary controlled area in the room where the laser is located. All unauthorized personal must leave the room and any personnel working in the immediate area of the laser room must be notified that the laser is being operated in an open mode inside the room. The operator must insure that no one is working overhead that could inadvertently look into the laser room from above, and a watch person must be stationed outside the room to insure that no unauthorized personnel enter the room while the box is open and the laser is on. The operator must also check that the "LASER ON" warning light comes on outside the room when the laser is operated with the interlocks defeated. All operators in the room must wear appropriate safety goggles as indicated above during the alignment procedure. **However, never view the beam directly even with safety goggles.** The alignment can be checked by inserting a small white card into the beam path and viewing the fluorescence from the card **from the side** while wearing safety goggles. Whenever possible, the alignment should be done with the laser power as low as possible.

  Alignment of the internal optics of the laser requires removing the main cover from the laser and defeating the factory supplied interlocks. These interlocks are in addition to those on the interlocked box. Safety goggles must always be worn whenever working with the laser with the cover removed and the laser energized. In addition to potential exposure to the primary beam, hazardous voltages may also be present on certain internal components of the laser. Any work with the main cover off and the power on requires an evaluation by a Work Control Coordinator to determine whether the task requires Enhanced Work Planning.

- **Interlock testing procedure:**

The interlocks on the laser box must be tested every six months and documented in the logbook located near the laser.

The interlock test procedure is as follows:

1. Put on laser safety goggles.
2. Start the laser and bring it into its normal operating conditions according to the procedure described in the manufacturers operating manual.
3. Turn on the bias voltage to the trigger photodiode inside the laser box and verify that it is set to +25V.
4. Connect a fast oscilloscope to the output connector on the laser box labeled "Trigger Output"
5. Verify that the photodiode is detecting light from the laser pulse/
6. Open the lid of the right side of the laser box slightly until the shutter is heard to drop into place and verify that the signal from the photodiode disappears.
7. Repeat step 6 for the left side of the box.
8. Record the results of the test in the logbook located near the laser.

Maintenance:

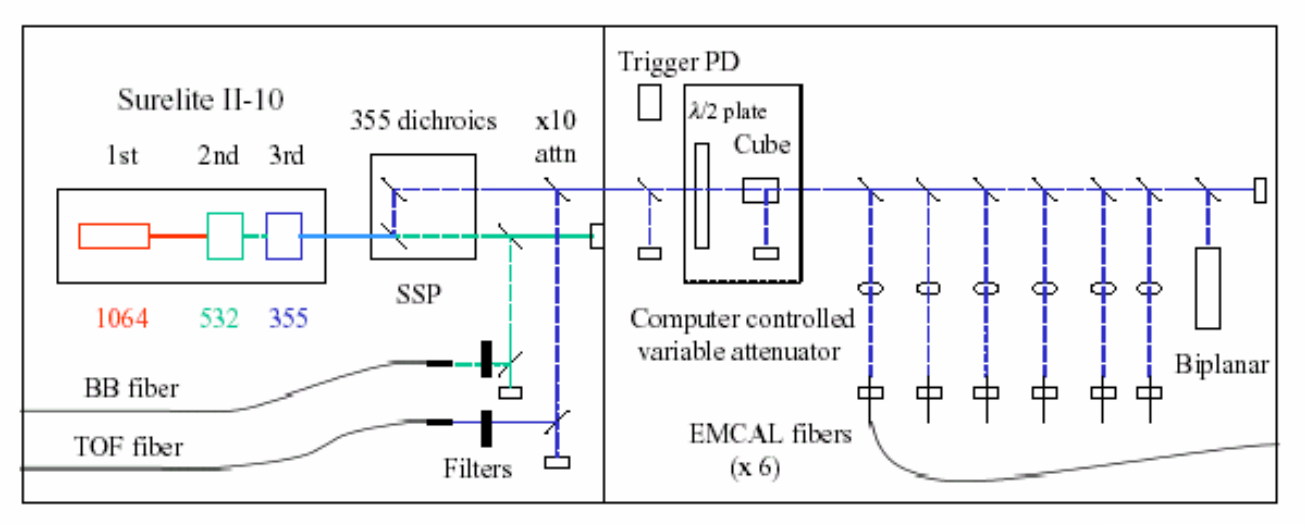
- Routine maintenance for the Surelite involves periodically changing the flash lamp and cooling water filter, and cleaning the beam optics. Depending on usage, this maintenance may be performed on the order of every few months. Since these operations are done with the laser off,

there are no hazards associated with these procedures. However, care should be taken when changing the flash lamp, which is delicate and can be easily broken.

Service:

- Any service beyond routine maintenance would be performed by a factory-trained technician or the laser would be sent back to the factory for service.

PHENIX YAG laser and Beam Splitter Optics



< 1 microjoule/pulse

< 5mJ/pulse

BROOKHAVEN NATIONAL LABORATORY
MEMORANDUM

To: Asher Etkin
From: Craig Woody
Date: August 10, 1998
Subject: Operation of YAG laser in building 1008A

The PHENIX electromagnetic calorimeter, time-of-flight detector and beam-beam counter systems will utilize a Class IV Nd:YAG laser as part of their calibration and monitoring systems. It is planned that this laser will be located inside a specially enclosed "laser hut" in the electronics area of the PHENIX Counting House (Bldg 1008A).

The laser and beam splitter is housed inside a totally enclosed and interlocked box which has been inspected and approved by the BNL Laboratory Laser Safety Officer, Chris Weilandics, and is described in detail in memos of 9/12/96 and 8/6/98, copies of which are attached. The box is divided into two compartments, one which contains Class IV laser light, and another which contains only Class III. The box is interlocked with four redundant interlock switches, two for each compartment, which are connected to the factory installed safety interlock system of the laser. Opening either compartment of the box will activate an intercavity shutter inside the laser and stop the laser from firing. Because the laser and any Class IV light is totally contained within the interlocked box, the laser has been approved for operation in a normal lab area, and has been operated as such for almost 2 years in a standard laboratory room of the physics building (Room 2-83 in building 510A). It is therefore proposed that the laser be operated in a similar manner in 1008A, with the additional safety factor that the laser and it's box will also be contained within the laser hut.

The laser hut is an area approximately 9'x17' surrounded by four 8' high walls. In order to provide ease of ventilation, there is no roof on the hut. There is only one access door which will be locked at all times except for authorized entry. The laser will be located in the rear part of the hut with no direct light path from the beam to the door. A yellow flashing caution light will be activated by the safety interlock system of the laser box whenever the box is open. This will indicate to all personnel in the electronics area of building 1008A that the box is open and that no work is permitted in the area above a height of 8'. We ask that this system be inspected and approved by the Laboratory Laser Safety Officer and the RHIC ES&H Coordinator when it is installed.

The accompanying procedure deals with the operation of the laser in this location.

Procedure for Operating YAG Laser in Building 1008A

1. The laser shall only be operated inside the laser hut in the electronics area of building 1008A.

2. The laser shall only be operated by authorized personnel. To be authorized to operate the laser, you must pass the BNL Laser Safety Training Course (IND011), take the required eye exam, and receive instructions on the safety systems and use of this particular laser. A list of authorized personnel will be posted outside the door of the laser hut.

3. The laser hut will be kept locked at all times any only entry by authorized personnel will be permitted.

4. The laser hut will be posted indicating the type, class and power of the laser inside, and that entry is permitted only by authorized personnel.

5. Laser goggles will be worn inside the laser hut at all times when the box is open for adjustments to the laser or alignment of the beam optics inside the box.

6. A flashing yellow caution light, which is clearly visible throughout the electronics area of building 1008A, will be activated whenever the laser box is open. This will indicate to all personnel in the area that the box is open, and that no work is allowed above a height of 8'. The circuit for activating the caution light will be integrated into the safety interlock system of the laser box.

7. The safety and interlock system will be tested a minimum of every six months to insure that it is functioning correctly and the results of the tests will be recorded in a logbook located in close proximity to the laser.

8. All operations of this laser shall be carried out in accordance with BNL ES&H section 2.3.1 and RHIC SEAPPM 2.3.1.

BROOKHAVEN NATIONAL LABORATORY
MEMORANDUM

To: Chris Weilandics
From: Craig Woody CW
Date: August 6, 1998
Subject: Modifications to YAG laser

In a memo dated September 12, 1996, the PHENIX YAG laser was described as having an intercavity beam aperture which limited the output power to 1/5 of its maximum value (from 210 mJ to 42 mJ). It was found that while this limited the total output energy by selecting only the central portion of the beam, the energy density was too high for injecting light into the delivery fibers for the electromagnetic calorimeter calibration system. The aperture has since been removed, and a beam limiting 10% transmitting mirror has been installed just outside of the beam separator package in front of the laser which allows the full beam spot to pass through, but limits the energy to roughly 20 mJ. This therefore limits the output power a factor of two more than the original aperture, and has the further advantage of reducing the energy density of the light injected into the fibers.

The previous memo also stated that when the Class IV compartment of the box is opened, the power to the laser head and cavity is shut off. This turned out to be impractical, and the interlock on the Class IV side of the box was wired the same way as on the Class III side. Therefore, in both cases, opening either side of the box causes an intercavity shutter to drop into place which stops the laser from firing. This intercavity shutter is part of the factory supplied safety system of the laser.

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

TO: Chris Weilandics

FROM: Craig Woody CW

SUBJECT: YAG:Nd laser for PHENIX

DATE: 12 September 1996

We recently purchased a Continuum Surelite II-10 YAG:Nd laser for use in the calibration system for the lead scintillator electromagnetic calorimeter for the PHENIX experiment at RHIC. This is Class IV laser with a primary energy of 650 mJ at a wavelength of 1064 nm, and is equipped with a second harmonic generator which produces 260 mJ of frequency doubled light at a wavelength of 532 nm, and a third harmonic generator which produces 215 mJ of frequency tripled UV light at wavelength of 355 nm. The beam diameter is 7 mm, which implies that the energy densities are 1.69 J/cm^2 at 1064 nm, 0.66 J/cm^2 at 532 nm, and 0.56 J/cm^2 at 355 nm. The maximum repetition rate was set at the factory to be 10 Hz.

During normal operation in the PHENIX calorimeter calibration system, we will only be interested in the 355 nm light, and typical repetition rate will be approximately 1 Hz. The laser is equipped with a factory installed intercavity beam aperture which limits the light output at 355 nm to 42 mJ. At this energy, the average power is 420 mW at the maximum repetition rate, and 42 mW at 1 Hz. Therefore, in terms of the maximum energy density and average power with the beam aperture in place, the laser will operate as a Class III device (< 10 J/cm^2 and < 500 mW average power).

Because we are only interested in the 355 nm light, we wish to enclose the laser inside a light tight box which use only the reduced energy Class III beam. Our proposed arrangement is shown in the accompanying drawings. The laser is equipped with a factory supplied beam separator and beam dump which will bring out the 355 nm beam and block the residual 1064 nm and 532 nm beams. The 355 nm beam will be divided into six individual beams of equal energy by a system of six beam splitter mirrors. Each beam will be focused with a quartz lens onto a 600 μm quartz fiber which will deliver the light to the PHENIX calorimeter. The laser and beam separator package are located on the left side of the box (Class IV compartment), and the beam splitter and fiber delivery system are located on the right side (Class III compartment). The two sides are divided by a light tight barrier and only the 355 nm beam enters the Class III compartment. We propose to independently interlock both compartments such that access to either side of the box will prevent any light from reaching the Class III compartment. The Class IV compartment will have a hard-wired double interlock in series with the internal safety interlock of the

laser head. This will be equivalent to the interlock on the cover of the laser housing itself. If this interlock is interrupted, it will shut off all power to the laser head and cavity. The Class III compartment will have a separate double interlock in series with the beam shutter, such that any interruption will cause the intercavity beam shutter to drop into place and block the primary beam. The reason for this type of interlock for the Class III compartment is that we expect to require frequent access to this side of the box in order to align the beam splitter optics, and shutting off the power requires a 30 minute recovery time to reestablish thermal stability. However, the shutter interlock is still fail-safe in the sense that once the interlock is interrupted, it requires the operator to manually open the shutter again after the interlocks have been restored.

We do not expect to require access to the Class IV compartment except during the initial alignment of the beam separator optics and occasional adjustment of the harmonic generators. Adjustment of the harmonic generators requires access to two adjustment knobs located on the outside of the laser housing, and does not require removal of the laser housing itself. The initial alignment will be carried out in a Class IV certified safety room in the Physics Department. Once this initial alignment is done, we will enclose the Class IV primary beam in its own separate housing inside the Class IV compartment. The result of this will be that *no laser light of any kind* will then be present inside the Class IV compartment during normal operation. This will allow us to remove the cover of this compartment when necessary and make adjustments to the harmonic generators. During this time, a power meter will be installed in the Class III compartment, which will be closed and interlocked while the harmonic generators are being tuned.

We feel that we have carefully considered all of the safety aspects regarding the installation and use of this laser for our application, and we ask that you approve our proposed implementation plan. We nevertheless welcome your comments and suggestions regarding any aspect of this plan, and invite you to come and inspect the installation at any time.

cc: S. Aronson
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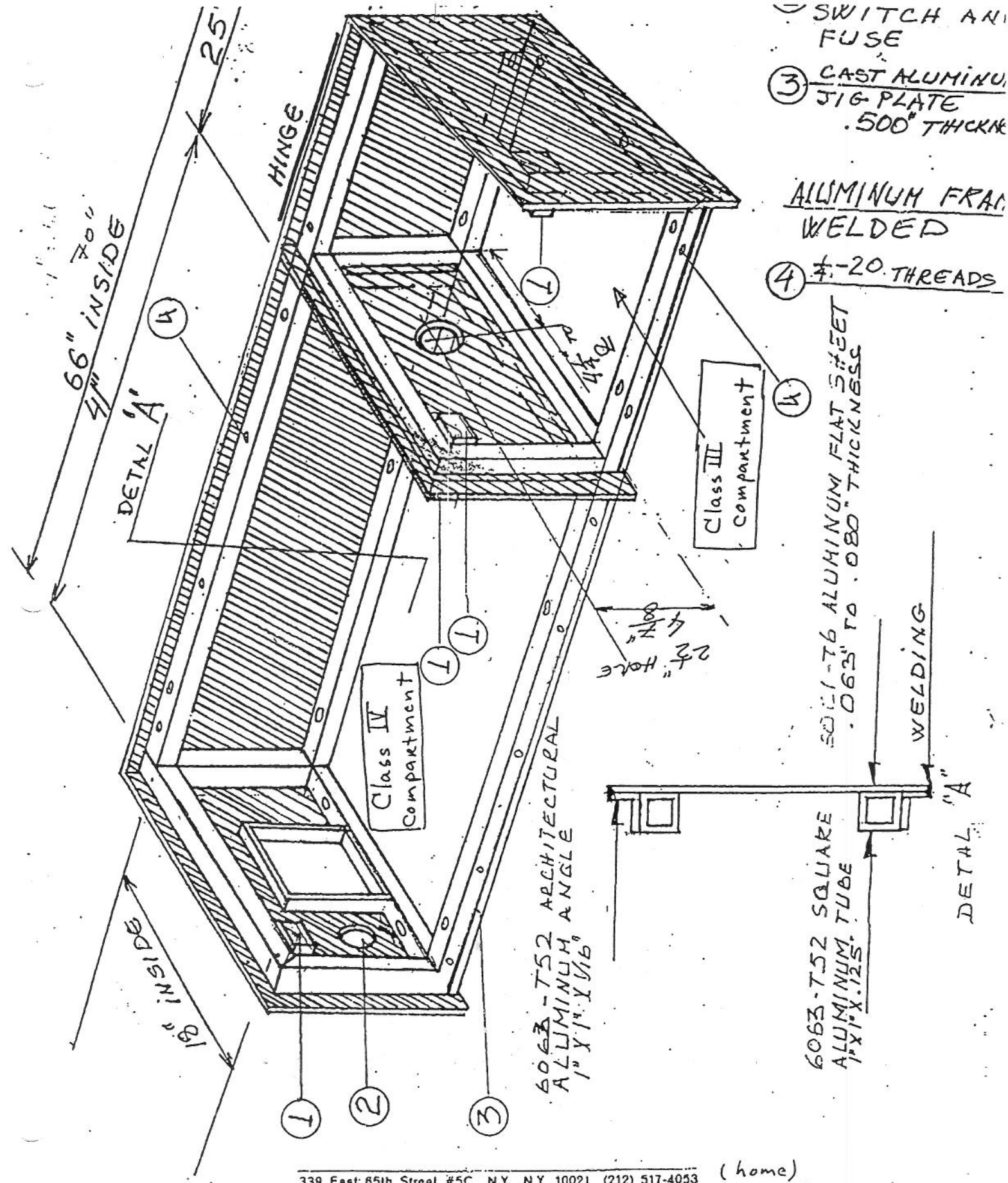

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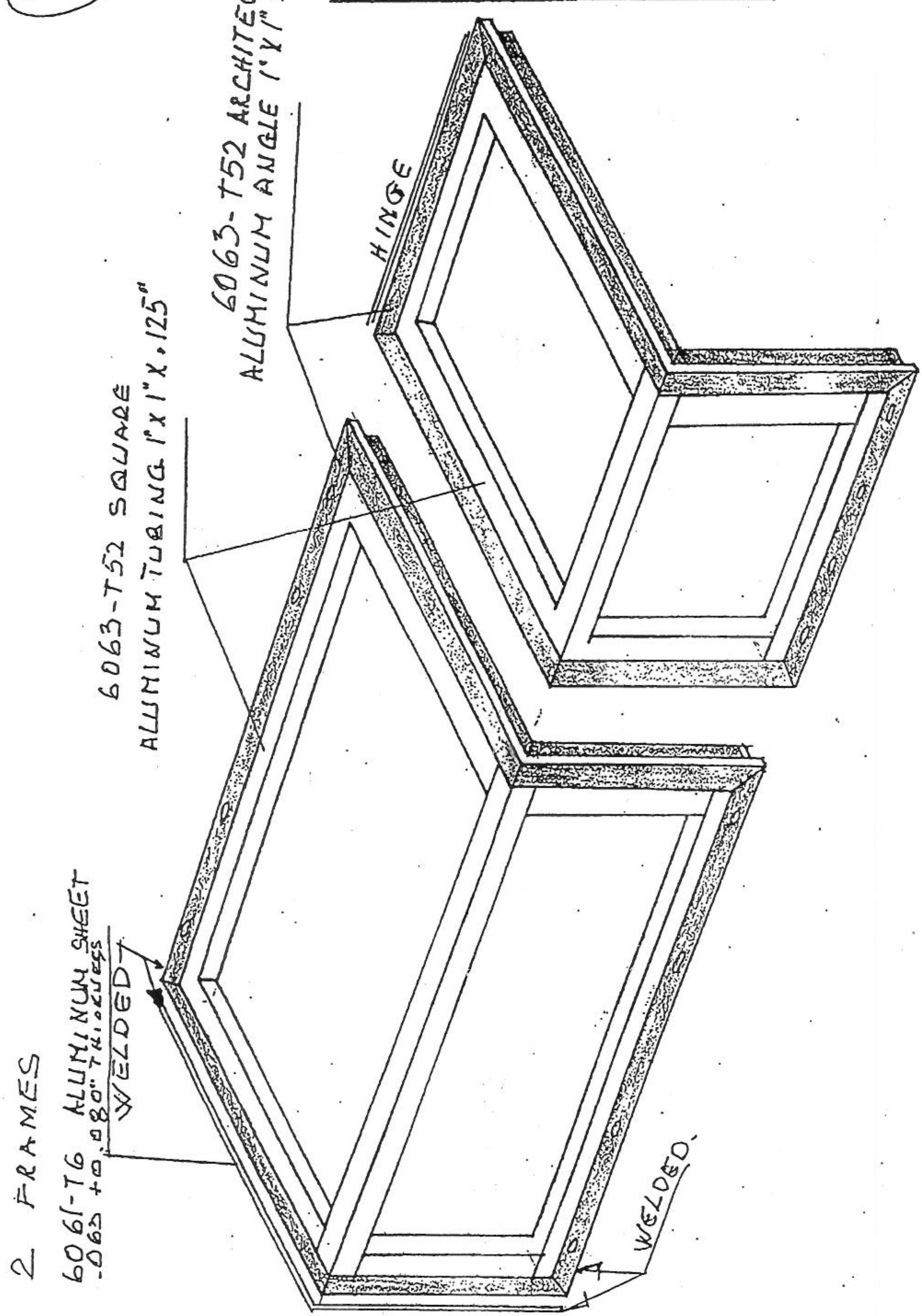

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